Effectiveness and longevity of fuel treatments in coniferous forests across California

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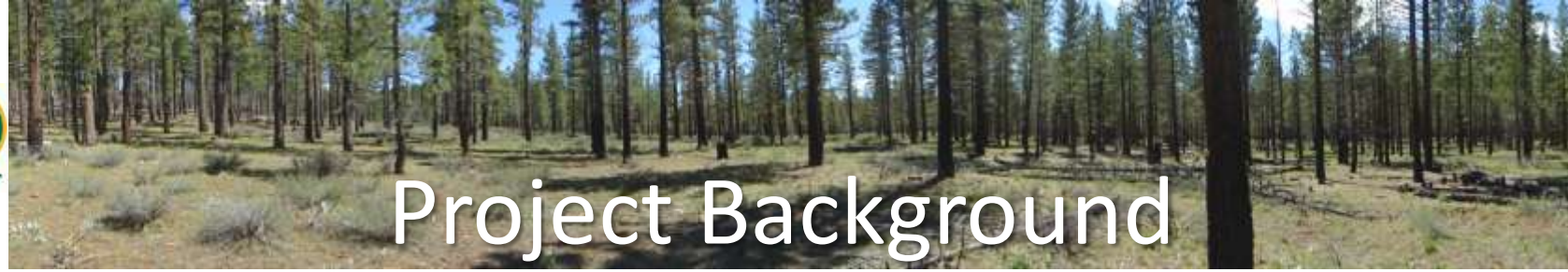
Research Need

- Many studies quantify the effect of fuel treatments on fuel loads, stand structure, and potential fire behavior before and **right after** treatment
- Very few studies look beyond initial effects on stands structure & fuel loads directly
- Even fewer on vegetation response & mortality/regeneration



Project Background

- Fuel treatment effects & effectiveness monitoring project in R5/PSW started in 2001
- Initially just prescribed fire treatments, then added mechanical treatments in later years
- Pre-treatment data collected on ~50 fuel projects on all National Forests in CA in many vegetation types
- Grant focused on **conifer dominated systems** treated by:
  - **MECH:** mechanical treatments included thinning followed by a surface fuel treatment (mastication, on-site hand or machine piling of materials that may or may not have been burned, or offsite biomass removal).
  - **FIRE:** prescribed fire treatments that were treated with fire only

Research Questions

Objective 1 – Determine length of time fuel treatments are effective at reducing undesirable fire behavior.

a) Measuring effects of treatments on stand structure and fuel loads over time

b) Modeling potential fire behavior with custom fuel models

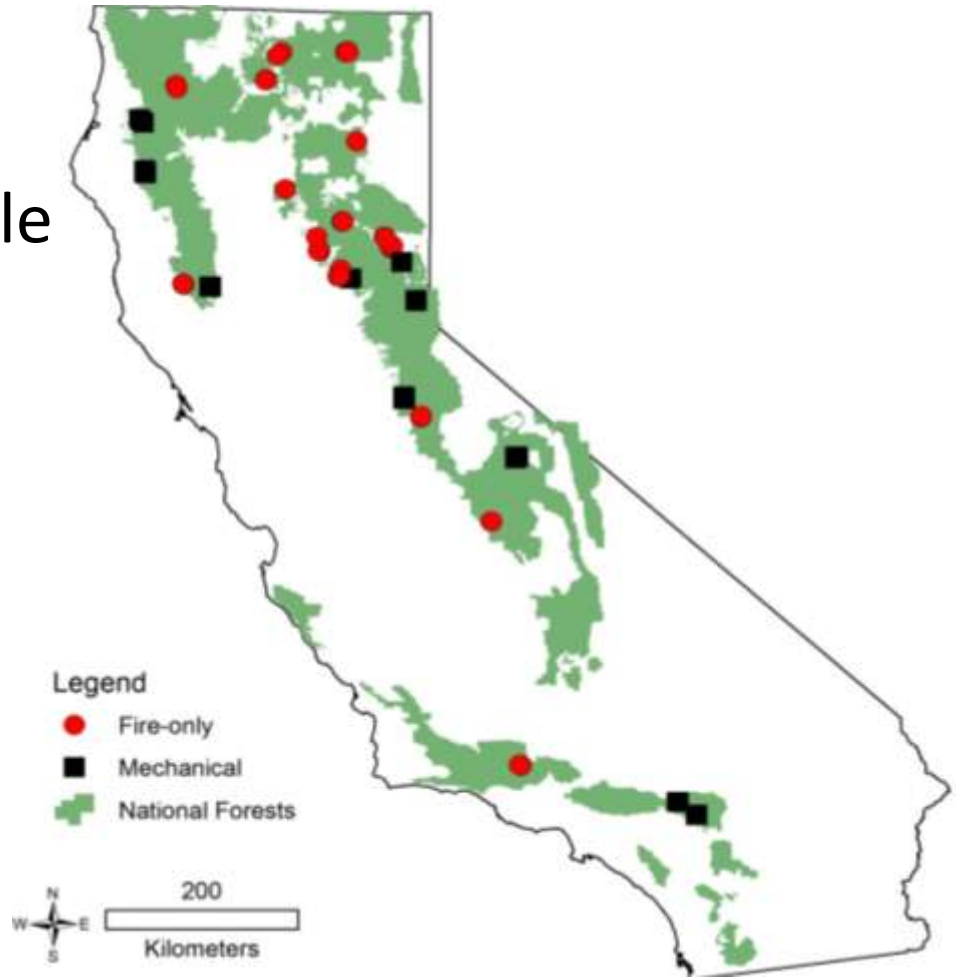
Objective 2 - Quantify the uncertainty associated with the use of standard and custom fuel models

Objective 3 - Assess prescribed fire effects on carbon stocks and validate modeled outputs

Methods

- 14 National Forests
- 28 fuel treatment projects
- 88 plots sampled at multiple time periods

P00: Pre-treatment
P01: 1 year post-treatment
P02: 2 years post-treatment
P05: 5 years post-treatment
P08: 8 years post-treatment
P10: 10 years post-treatment
-- 47 prescribed fire plots (FIRE)
-- 41 mechanical plots (MECH)



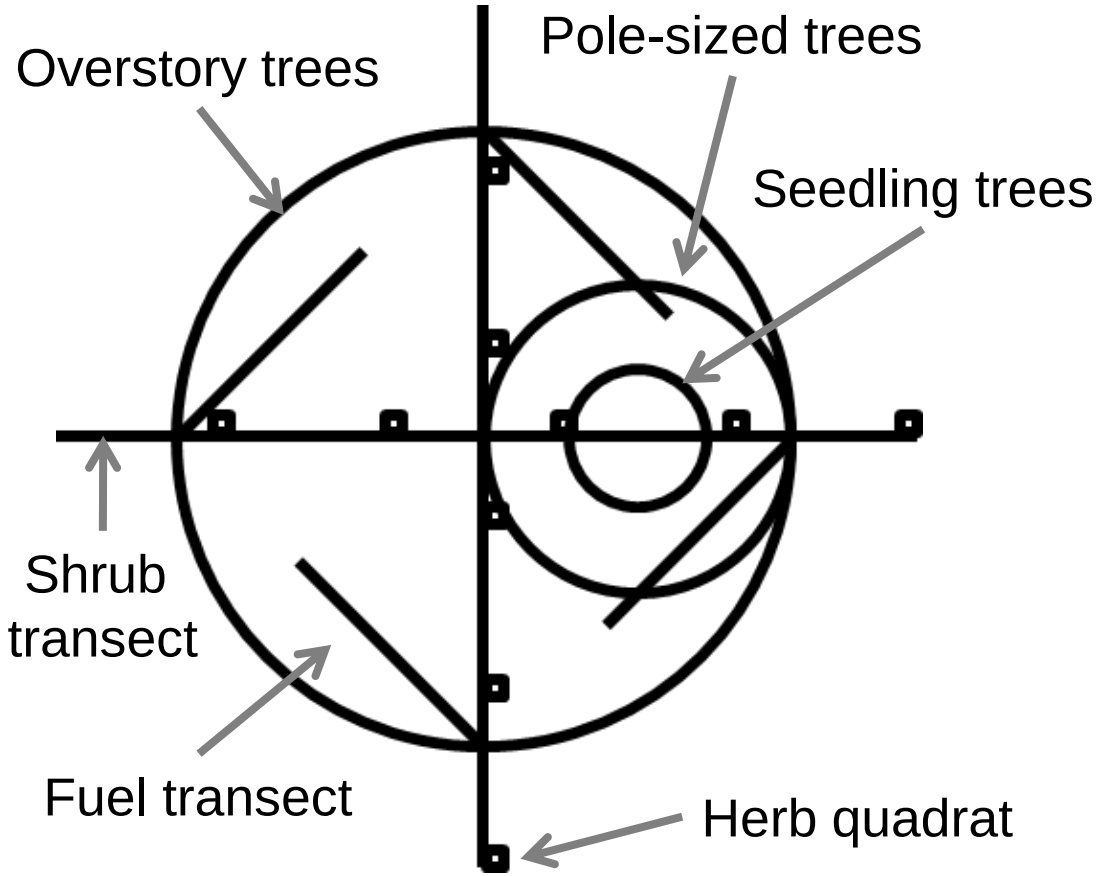
Methods

Field sampling overview

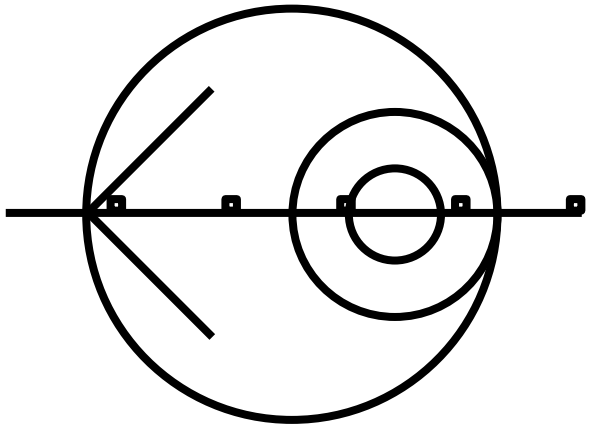
- Field sampling based on NPS Monitoring Handbook
- Random plot location within treatment
- Up to 6 plots installed per project area
- 2 types of plots: “detailed” & “fuels”
  - Trees inventoried only for detailed
- Data gathered on trees, downed fuels & understory plants

Methods

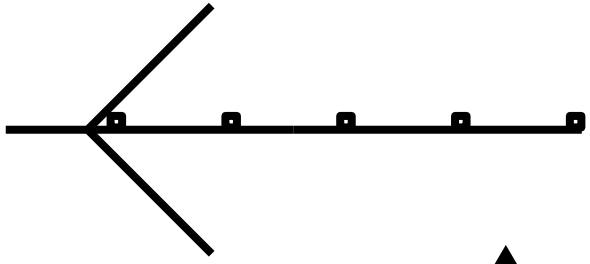
"Detailed" 2001-2002



"Detailed" 2003-2006



"Fuels" 2003-2006



Methods

Calculations

- Dead fuel biomass calculated using CA constants
  - *van Wagtendonk et al. 1996, 1998*
- Live fuel biomass calculated using FIREMON constants
  - *Lutes et al. 2006*
- Canopy metrics were calculated with the FFE-FVS (Fire and Fuels Extension for the Forest Vegetation Simulator)
  - Canopy base height, canopy bulk density, canopy cover, canopy height, tree density, quadratic mean diameter
- NEXUS used for the fire behavior modeling
  - Created custom fuel models from field calculated values

Methods

Why custom fuel models?

- Using the plots treated with prescribed fire we completed a comparison of modeled flame length and fire type using standard and custom fuel models.
  - We generally found good agreement between potential fire behavior using both types of fuel models
  - Custom fuel models were better able than standard fuel models to represent fine fuel loading and live fuel loads associated with treatments and the accumulation of fine fuels after the treatment.

Full details will be in:

Noonan-Wright, EN, NM Vaillant, AL Reiner. 2013. The effectiveness and limitations of fuel modeling using the Fire and Fuels Extension to the Forest Vegetation Simulator. Forest Science. In press.

Statistical Methods

The plots have been stratified by treatment and dominant forest type:

- FIRE-Mixed Conifer (MC)
- FIRE-Yellow Pine (YP)
- MECH-MC
- MECH-YP
- MECH-Red Fir (RF)

Used generalized linear mixed models (SAS Proc GLIMMIX) to test significance for fuels and stand structure. No stats on fire outputs.

Statistical Methods

Treatment-forest type	P00	P01	P02	P05	P08	P10
FIRE-MC	25	24	25	**4**	18	**6**
FIRE-YP	22	20	18	**8**	**11**	**7**
MECH-MC	24	24	19	19	17	**2**
MECH-YP	6	6	6	5	6	**0**
MECH-RF	11	11	10	**2**	**5**	**0**
Total	***88***	***85***	***78***	***38***	***57***	***15***

- Unbalanced sample size
  - Trends with low number of plots need to be looked at with caution!

Research Question

Determine length of time fuel treatments are effective at reducing undesirable fire behavior by

a) Measuring effects of treatments on stand structure and fuel loads over time

b) Modeling potential fire behavior with custom fuel models

FIRE-YP

Fire-only treatment in Jeffrey pine, Modoc NF (Hackamore)

Pre-treatment

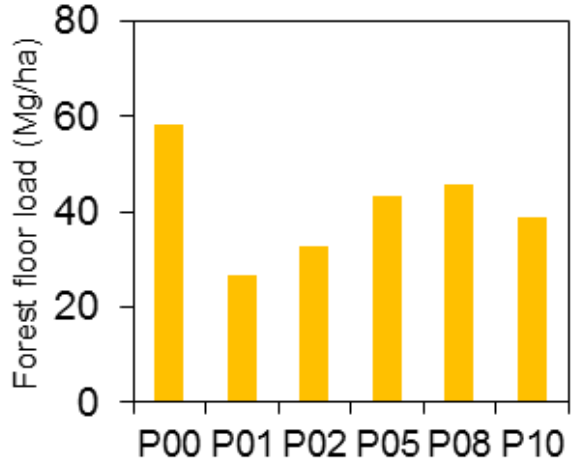
1-year post

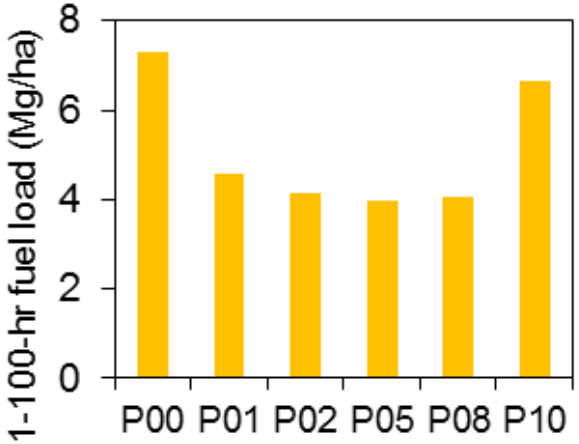
2-year post

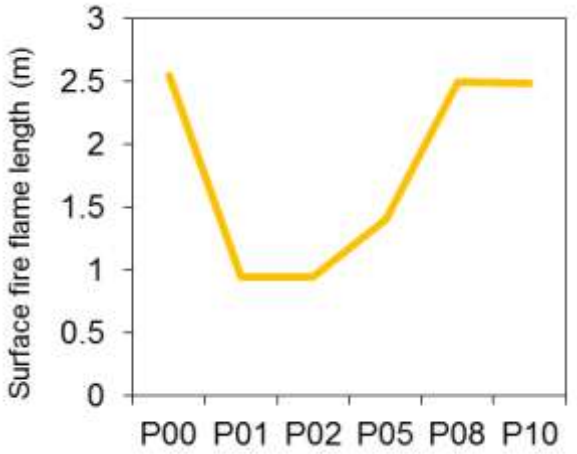
8-year post

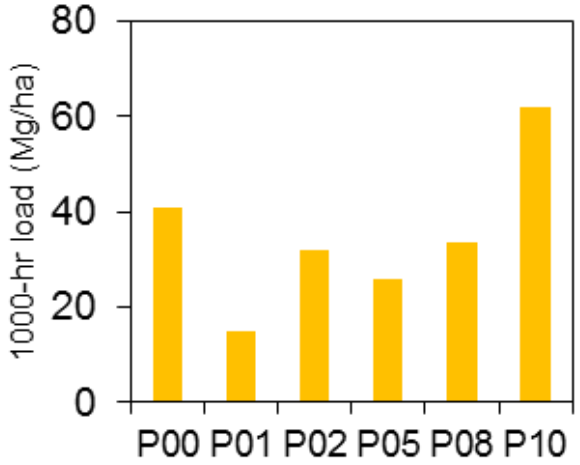
10-year post

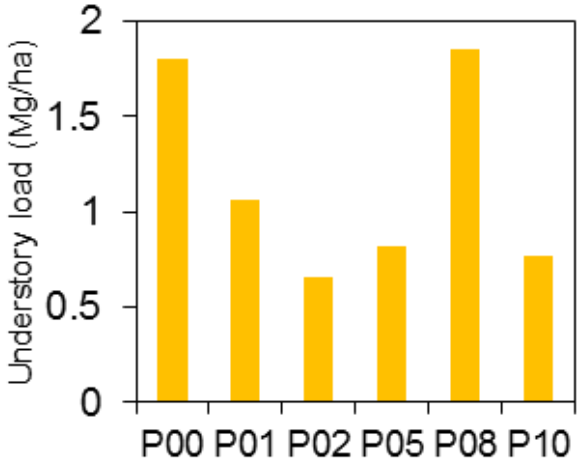
Fuel loads and surface fire flame length





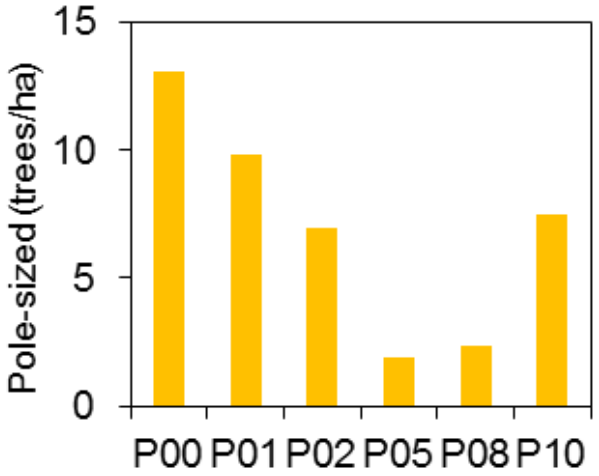


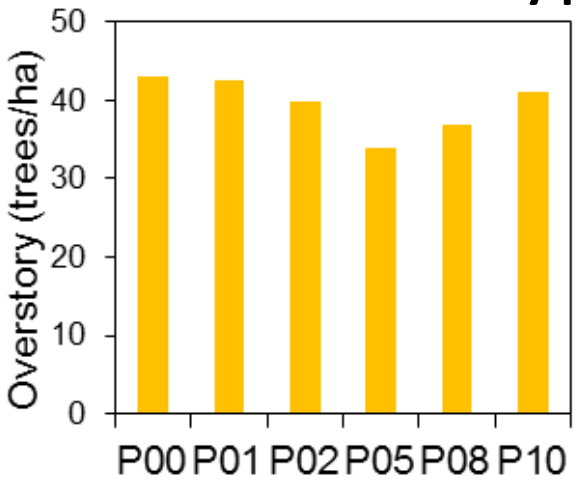


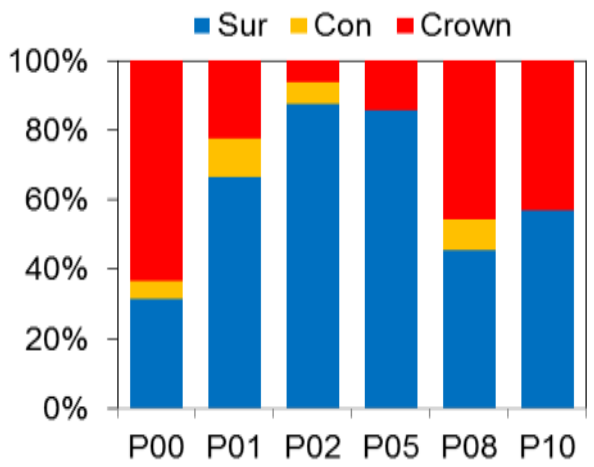


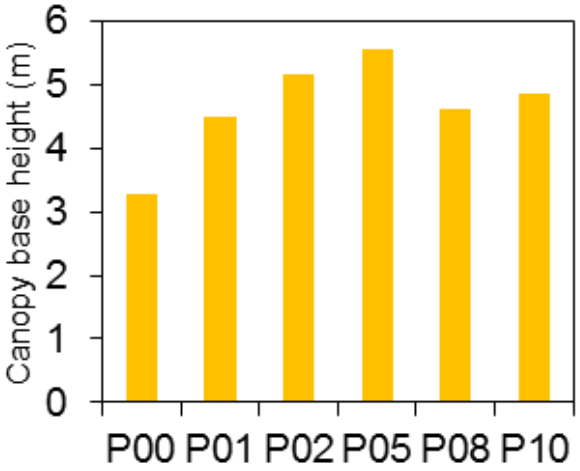
- Initial ↓ in fuel load =↓ SFL
- By P08 SFL ↑ from ↑ in live then (P08) dead fuels (P10)

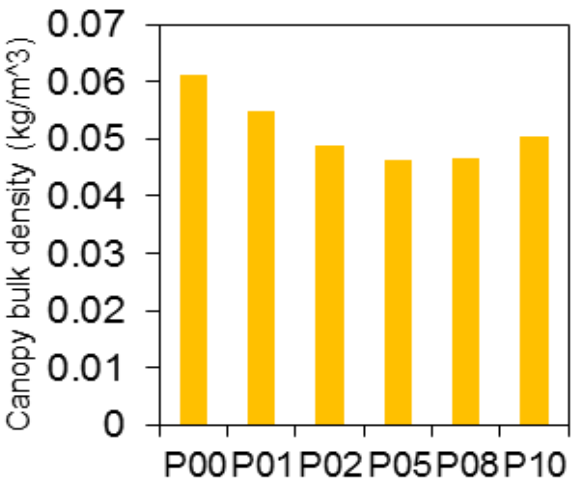
Stand structure and type of fire











- ✓ ↑ CBH & ↓ CBD lead to ↑ SF P02 & P05 than P01
- ✓ Potentially from delayed mortality

Fire-only treatment in mixed conifer, Klamath NF (Surrogate)

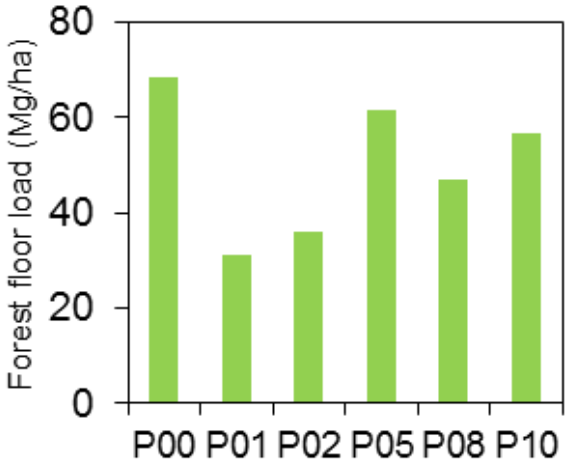
Pre-treatment

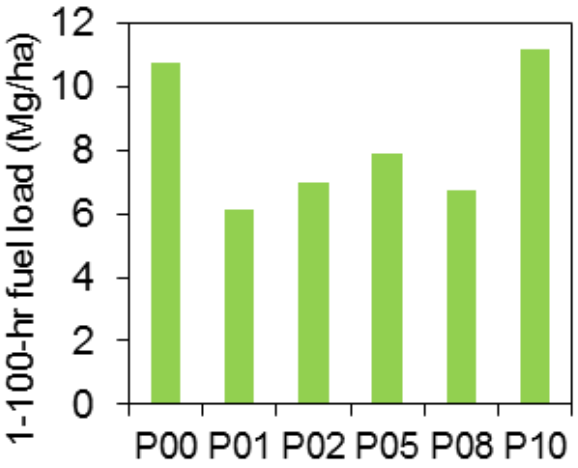
1-year post

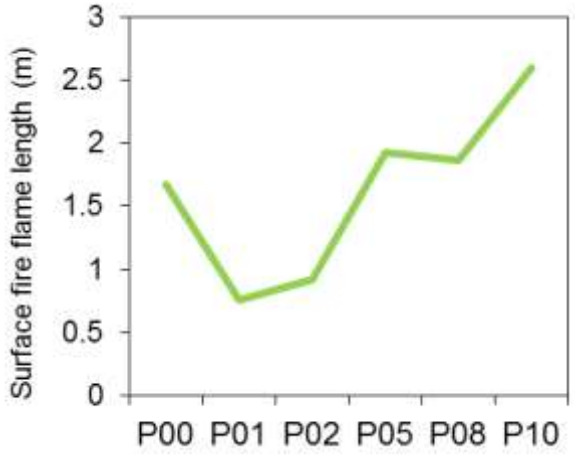
2-year post

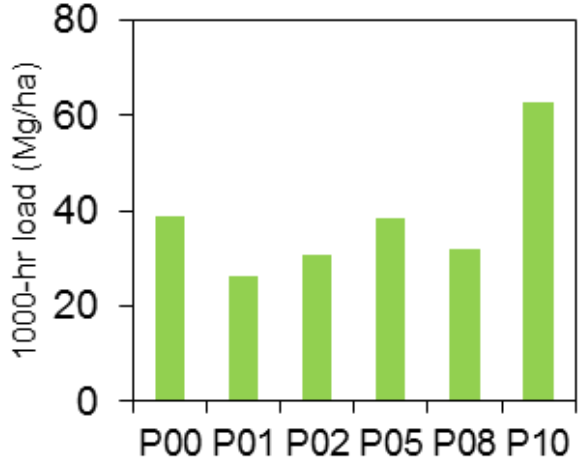
8-year post

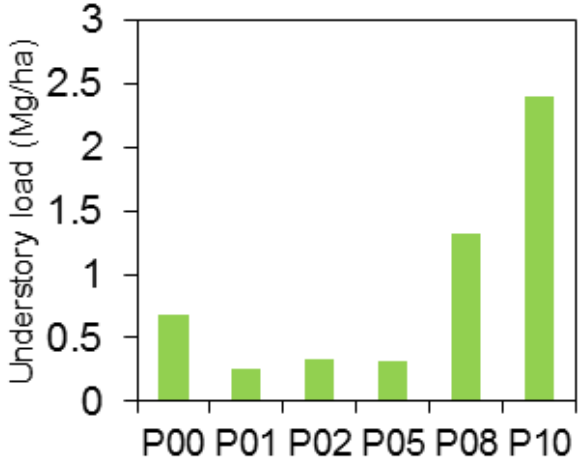
Fuel loads and surface fire flame length





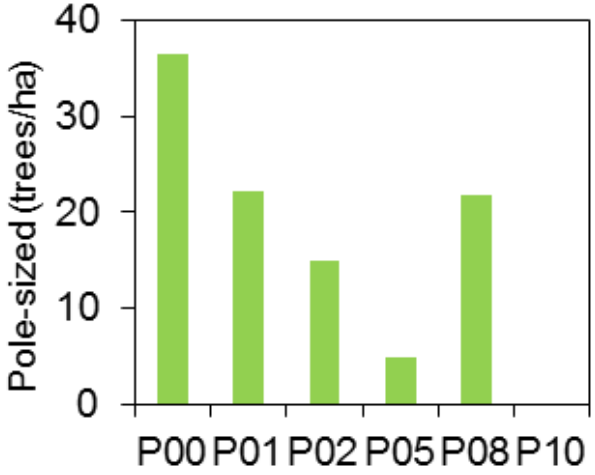


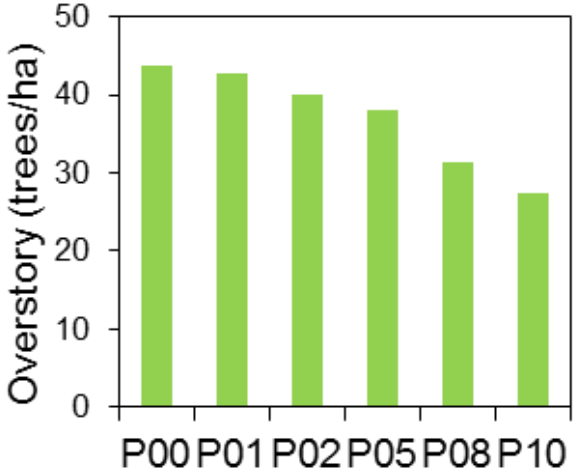


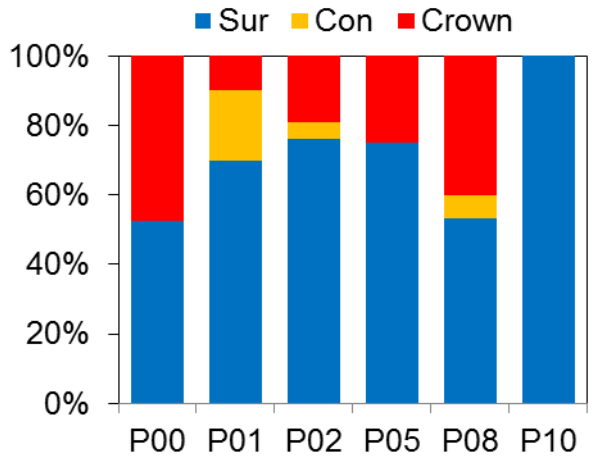


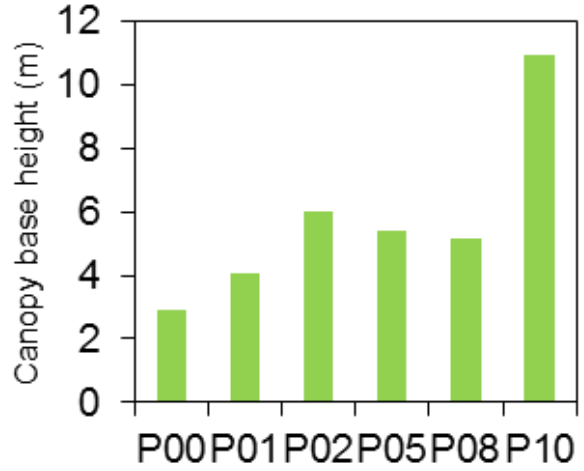
- Live fuels ↑ dramatically by P08
- Dead fuels bypass P00 by P10 leading to ↑ SFL relative to P00

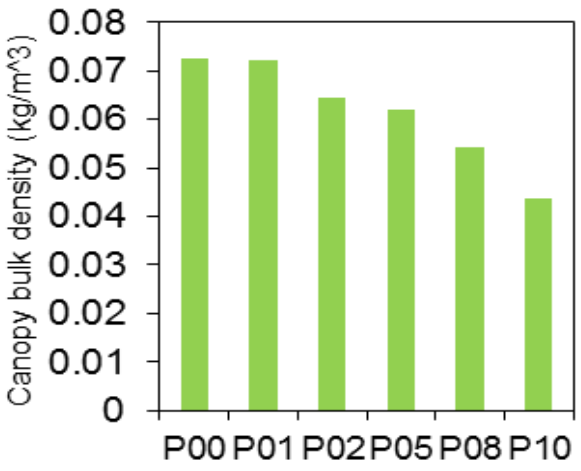
Stand structure and type of fire











Both P05 & P10 have very few plots, the trends are not accurate at those time periods

MECH-YP

Mechanical treatment in Jeffrey pine, Tahoe NF (Hot Springs)

Pre-treatment

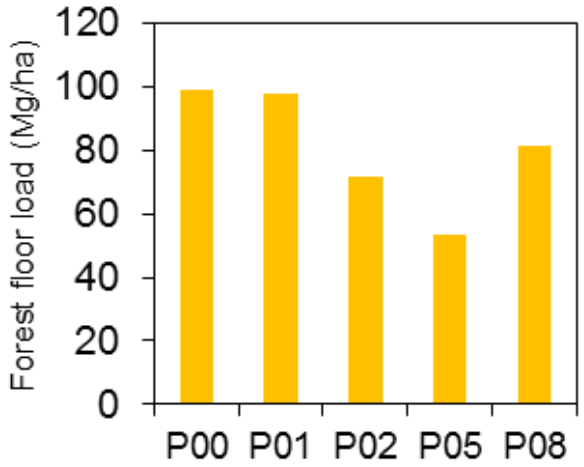
1-year post

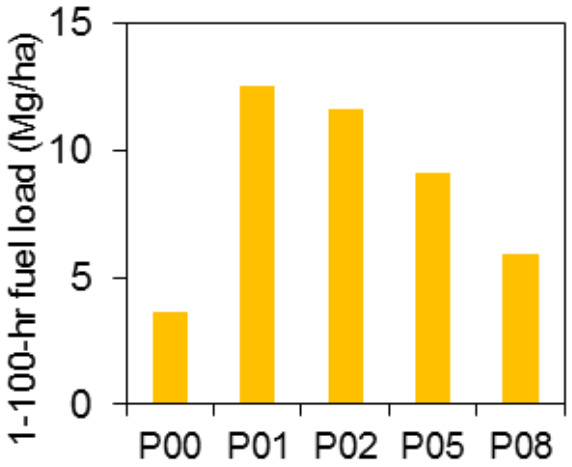
2-year post

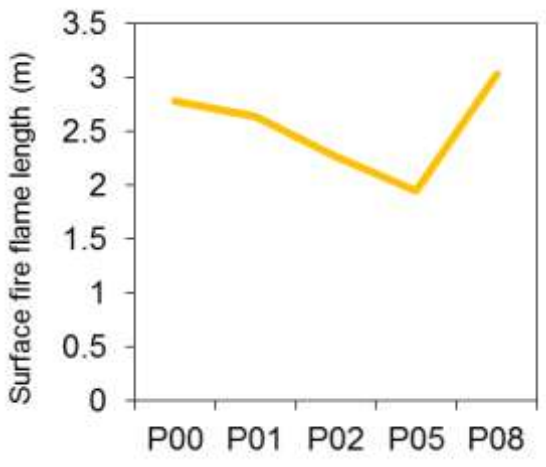
5-year post

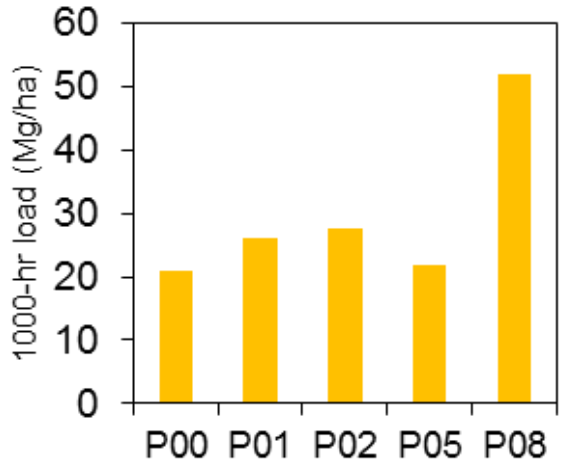
8-year post

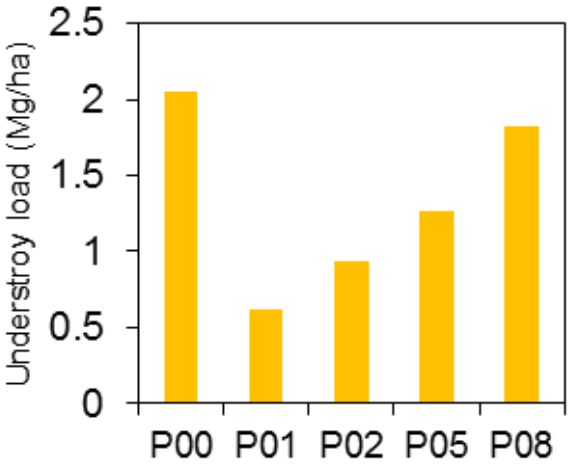
Fuel loads and surface fire flame length





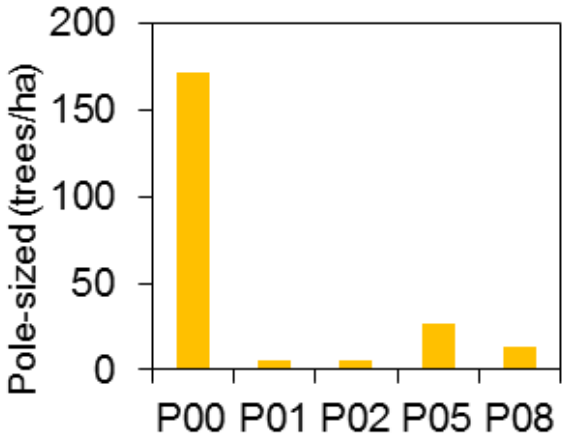


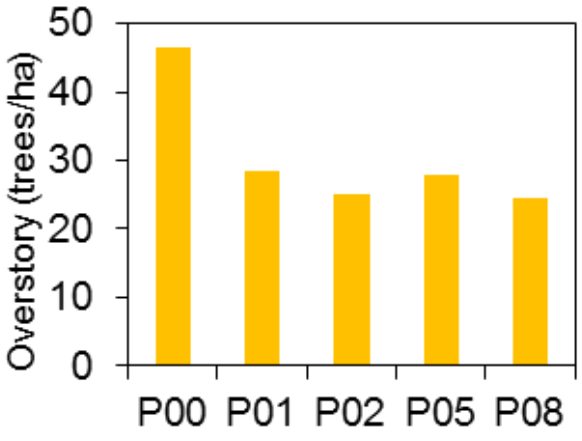


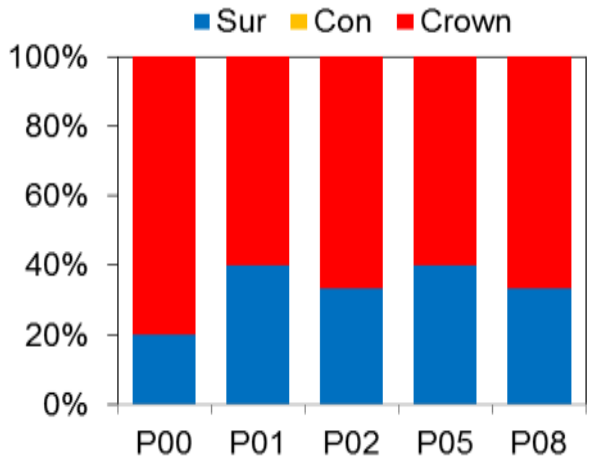


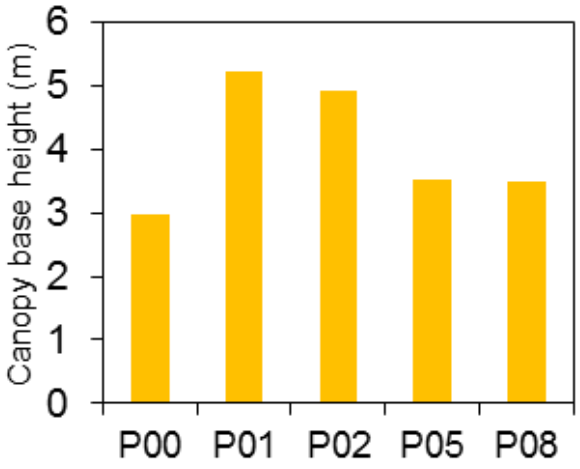
- Initial ↑ in smaller fuels then steady ↓ overtime
- ↓ in litter is driving the ↓ in SFL

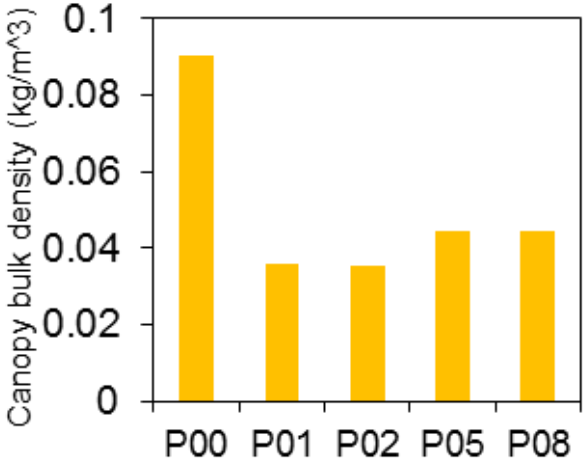
Stand structure and type of fire











Treatment ↓ in poles, ↑ CBH, and ↓ CBD = ½ crown fire potential

MECH-MC

Mechanical treatment in mixed conifer, Stanislaus NF (Big Love)


Pre-treatment

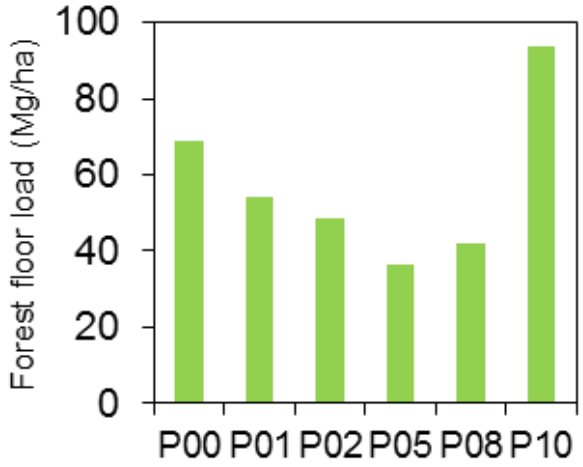

1-year post

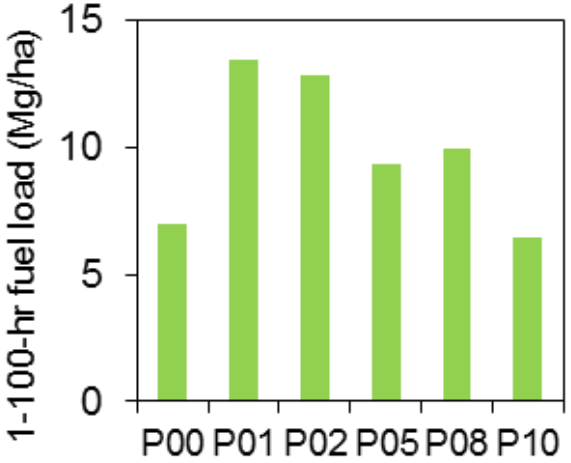

2-year post

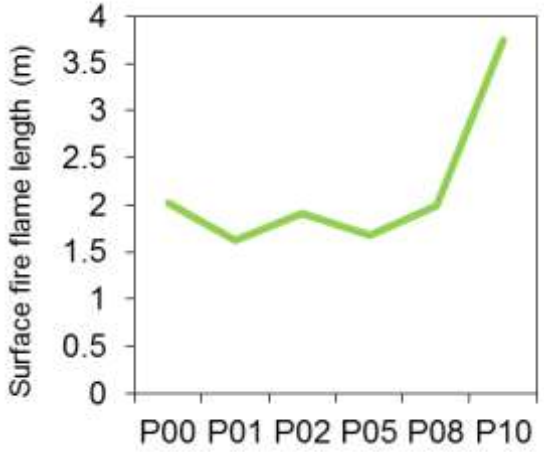

5-year post

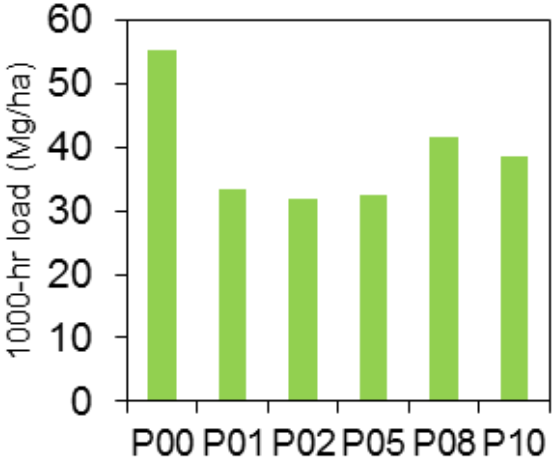

8-year post

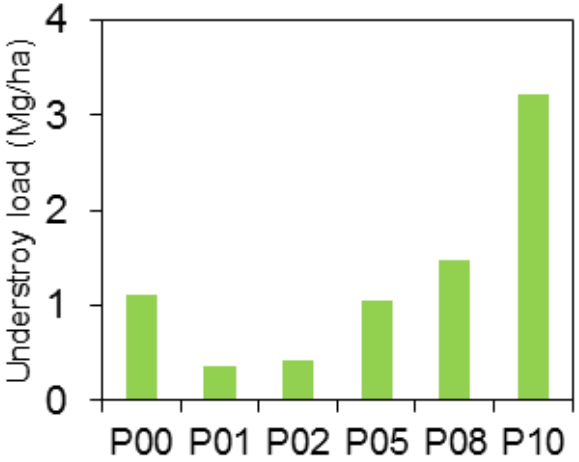
Fuel loads and surface fire flame length





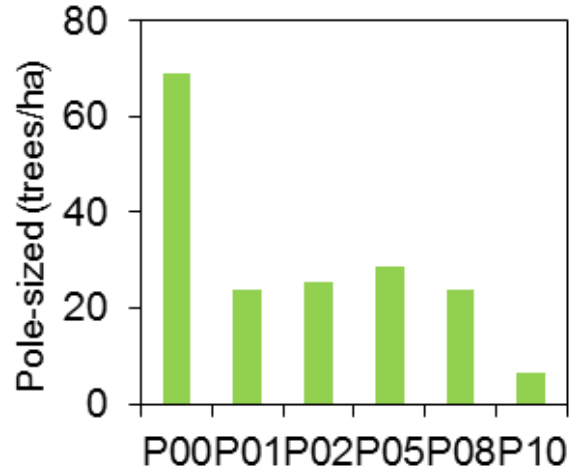


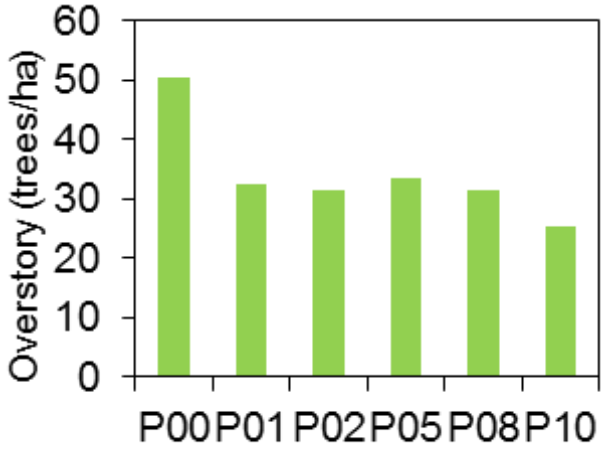


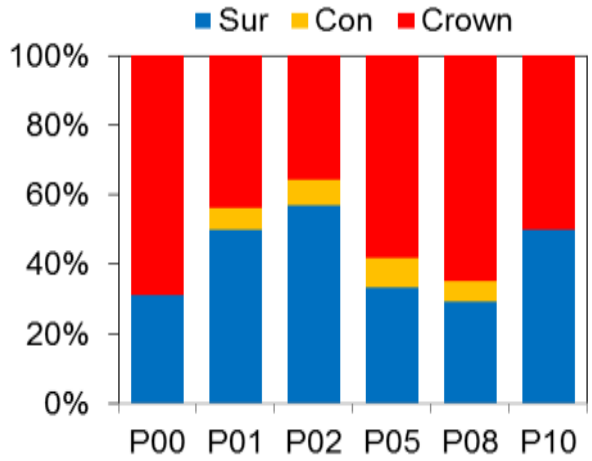


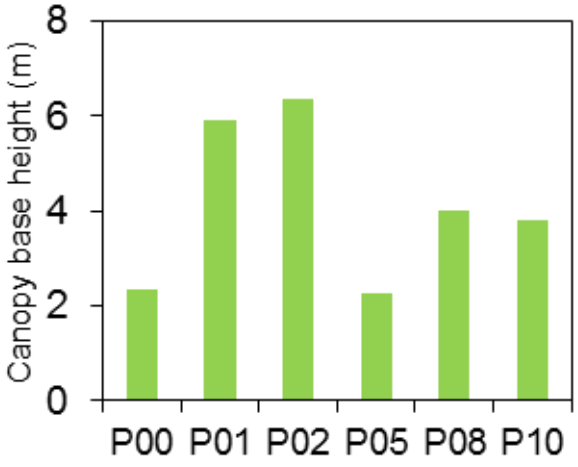
Even though 1-100-hr ↑ P01/P02 the proportion of smaller fuels ↓ resulting in ↓ SFL

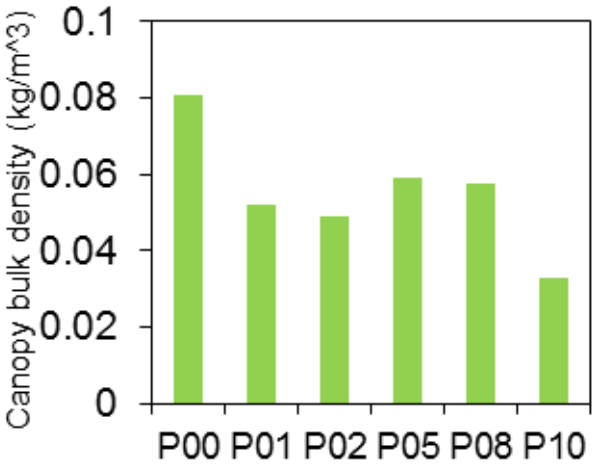
Stand structure and type of fire











Treatment ↓ trees, ↑ CBH, and ↓ CBD = ½ crown fire potential initially then CBH ↓ & CBD ↑ around P05

MECH-RF

Mechanical treatment in red fir, Lake Tahoe Basin (Dollar)

Pre-treatment

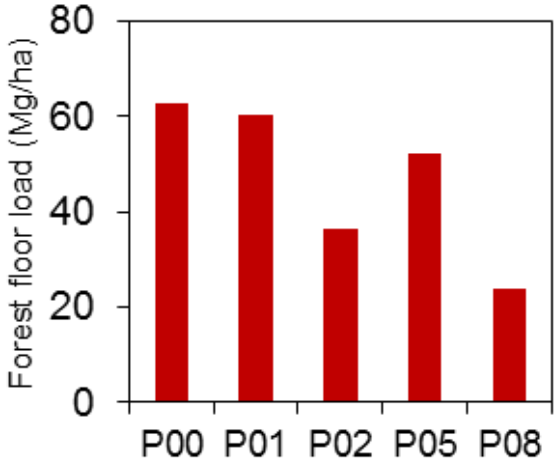
1-year post

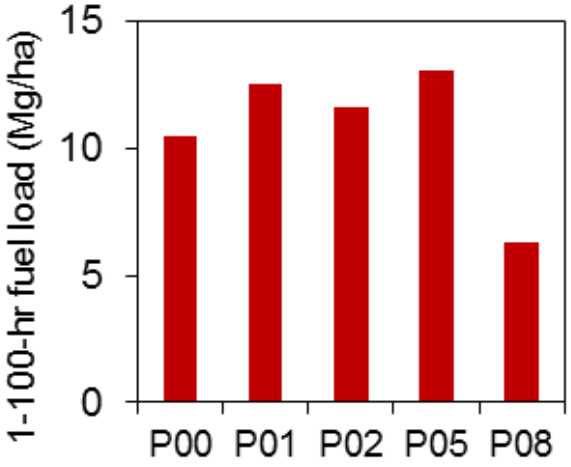
2-year post

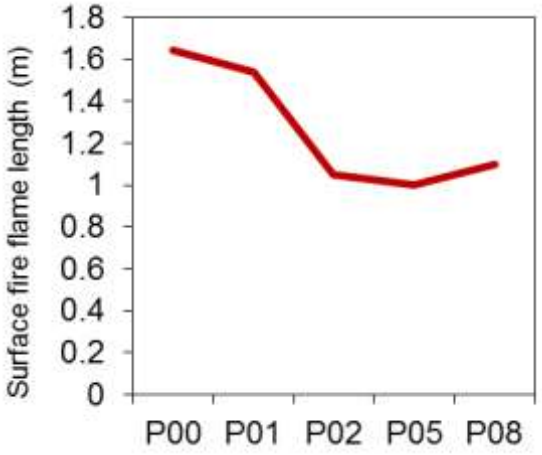
5-year post

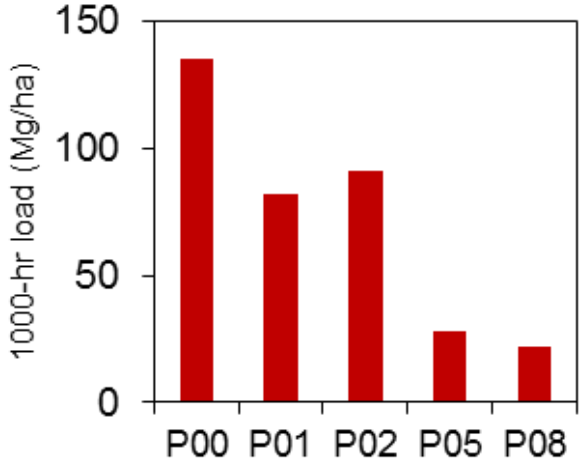
8-year post

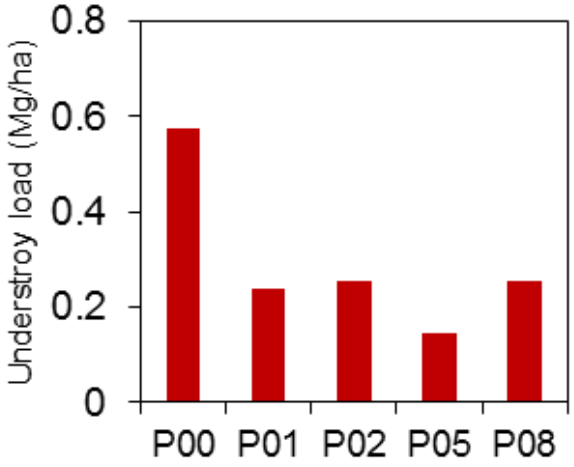
Fuel loads and surface fire flame length





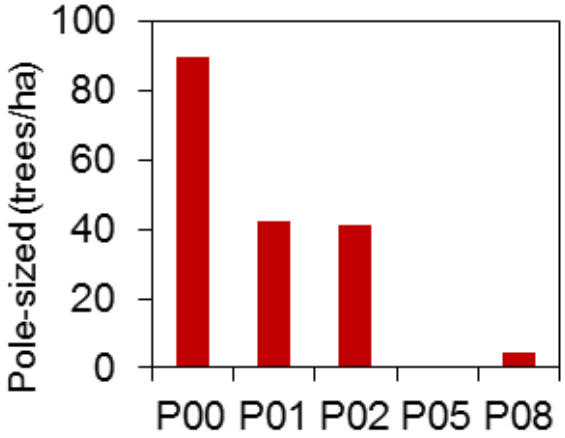


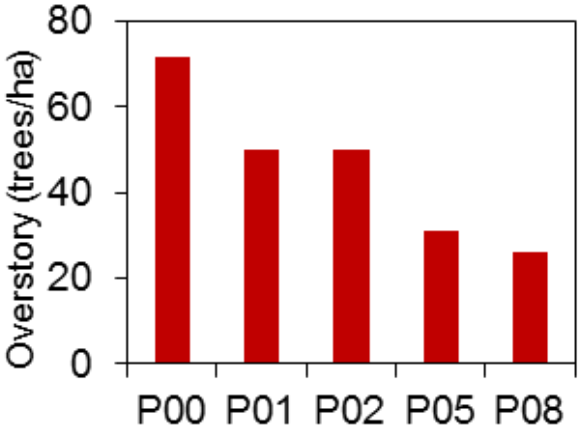


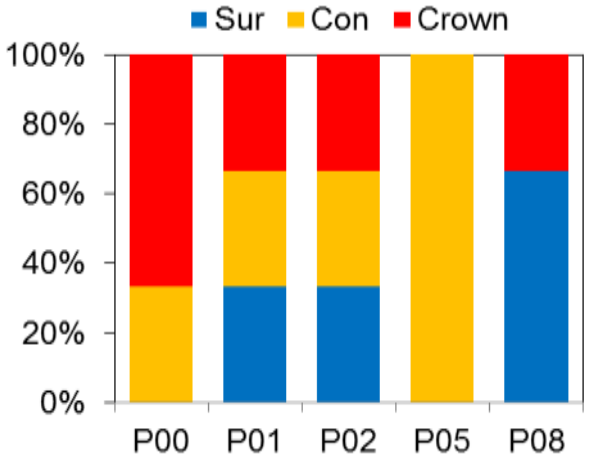


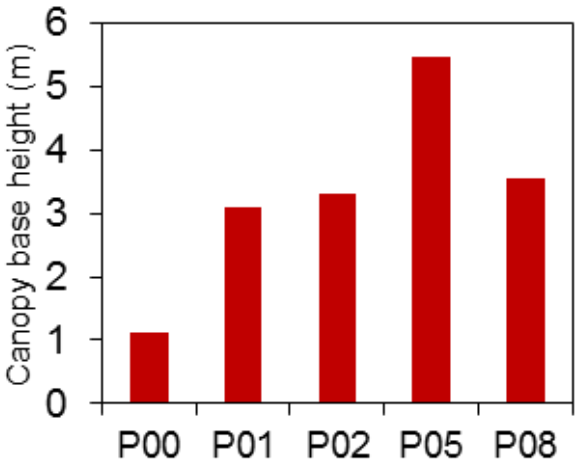
- ↓ in litter & live fuels are resulting in ↓ SFL
- Majority of the ↑ in smaller fuels is larger classes which don't effect SFL as much

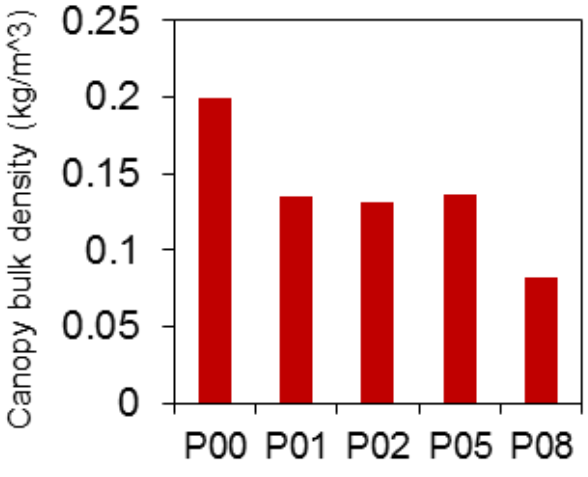
Stand structure and type of fire











- Transition from no SF to ~2/3 SF and CON from treatment P01 & P02
- P05 & P08 few plots does not fit trend

Summary: Fuel Loads

- Large spatial and temporal variability in fuel loads were found between and within treatment-forest combinations.
  - the trends for fire-only are “cleaner”
- Fire only-treatments initially ↓ loads followed by ↑
  - Except for 100-hr fuels = no trend
  - Total fuel load back to 73-79 % by P08
  - Match pre-treatment levels at about P10
- Mechanical treatments initially ↑ fine fuel loads (1-100 hr) and decrease others, but no trend over time
  - Partially because of sample sizes and lumping of mechanical treatments
- Understory live fuel load exceeded P00 levels by P08, if not sooner in FIRE and MECH treatments (MECH-RF was the exception to this trend).

Summary: Stand Structure

- Fire-induced delayed mortality contributes to slight decreases in canopy cover and CBD over time.
- MECH treatment removed trees of all size classes whereas FIRE treatment primarily impacted smaller diameter trees.
- Canopy characteristics were affected more by MECH (>25%) treatments than FIRE (~10-15%) treatments.
- For both treatment types CBH decreases in later years, but it remains higher than P00.

Summary: Fire Behavior

- Surface fire flame length (all plots)
  - ✓ Initial decreased from FIRE that started to increase by P05 and exceeded P00 by P10.
  - ✓ Variable and minimal change from MECH but some exceed P00 by P08.
- Crown fire (only plots with tree data)
  - ✓ FIRE decreased crown fire through P05/P08 but by P08/P10 it was close to P00 levels.
  - ✓ MECH about halved the incidence of crown fire with reduction continued through P08 and P10

Management Implications

- Despite extensive variability between plots, overall trends for treatment-forest combinations exist.
- Stand and canopy structure trends help inform both fuel and silviculture integrated objectives and prioritizations.

✓ Increases in live understory loads indicate potentially need for retreatment

✓ Total fuel load (forest floor, woody & live) in FIRE plots ~75% of pre- also indicate potential need for re-treatment

✓ MECH treatments would benefit from prescribed fire treatments to reduce still elevated fuel loads

Plea for more monitoring

Need for more long term monitoring

- To understand how fuels change from treatment over time
  - For all treatment types
- Monitoring needs to extend beyond the first year or two in fire treated areas to not miss delayed mortality
- Need to archive the data! FFI is a great tool

2-yr post *8-yr post* *10-yr post*

Future monitoring plans

- We want to continue to monitor the plots
  - We will be back in the field this summer to continue gathering data on 24 of the plots.
- We want to expand the scope of the project within CA and throughout the west
  - Do you have any existing monitoring data that could be added to this?
  - Please let us know and we will work with you to incorporate it!

Future work

- Continue to use the data to answer other questions beyond the grant objectives
  - Fire effects – use the post prescribe fire data collected on char, scorch, torch, and severity to see impacts on tree survivorship and plant response
  - Vegetation response – use the species level herbaceous and shrub data to explore vegetation response to both mechanical and prescribed fire treatments
  - And…..?

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- JoAnn Fites-Kaufman who initiated the project and obtained the funding for the first 6 years
- Fuels, fire, GIS, and silviculture staff from all the forests involved
- Field crews – especially K. McCrummen & T. Decker
- Sylvia Mori (PSW) and Ben Rau (ARS) for statistical guidance

2013 plots

FOREST	PROJNAME
SAN BERNADINO	ANGELUS OAKS
INYO	MAMMOTH FB
KLAMATH	EDDY
LASSEN	SWAIN
MODOC	HACKAMORE
PLUMAS	SPANISH CAMP
PLUMAS	BRUSH CREEK
SIX RIVERS	MAD RIDGE FB
STANISLAUS	MCKAY
TAHOE	MOON UNIT